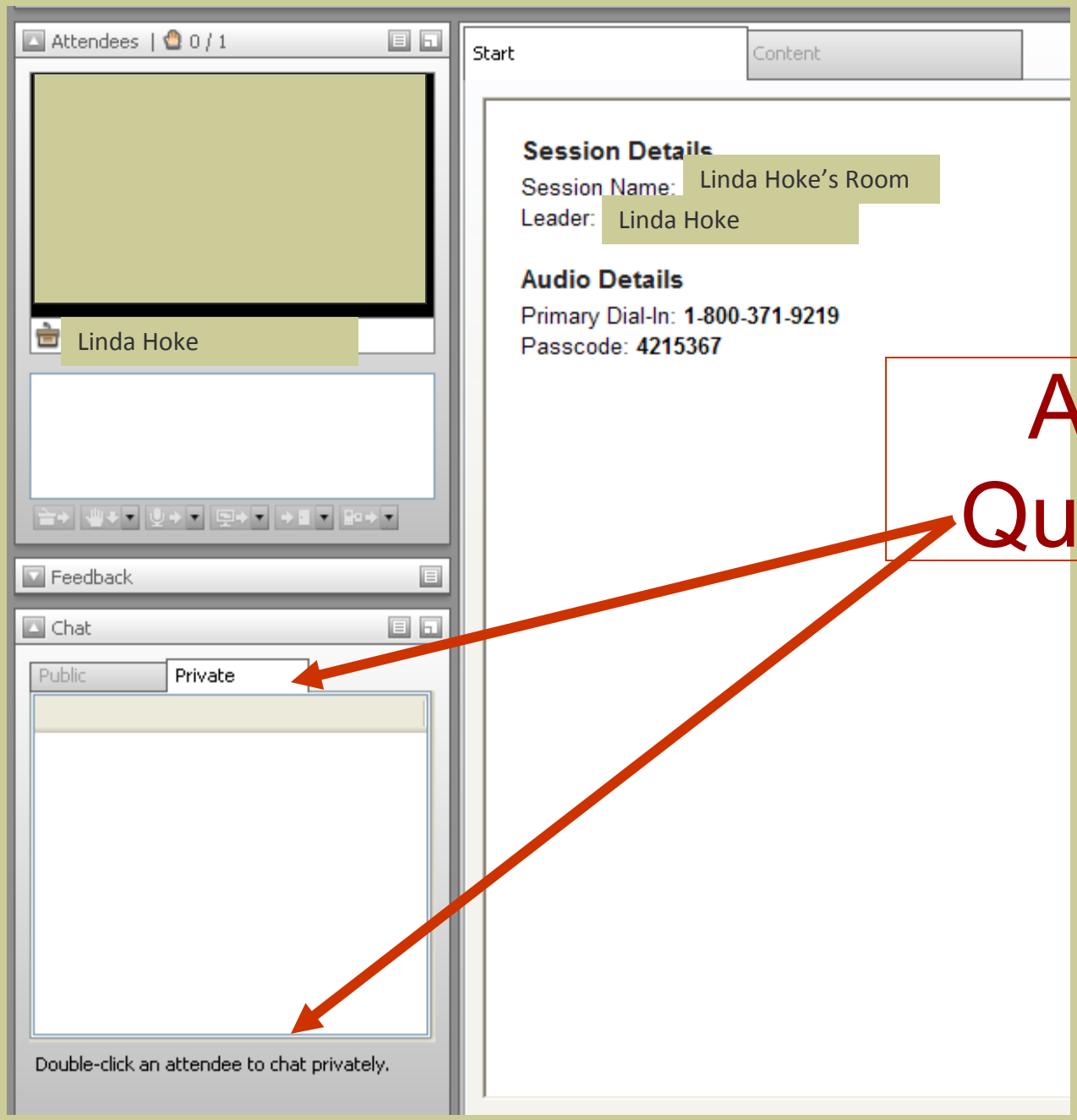
southern growth policies board

The Advanced Materials Webinar Series: Bioplastics

Southern Advanced Materials in Transportation Alliance (SAMTA)

Today's Objectives

- Assess the economic development potential of bioplastics.
- Explore research questions and their relevance for the South.
- Gauge further interest in pursuing this material as a working group.



Asking Questions

Today's Speakers

- **Ramani Narayan**, University Distinquished Professor, Chemical Engineeering & Materials Science, Michigan State University

- **Melissa Hockstad**, Vice President, Science, Technology & Regulatory Affairs, The Society of the Plastics Industry

MICHIGAN STATE UNIVERSITY

January 12, 2011

Understanding BIOPLASTICS

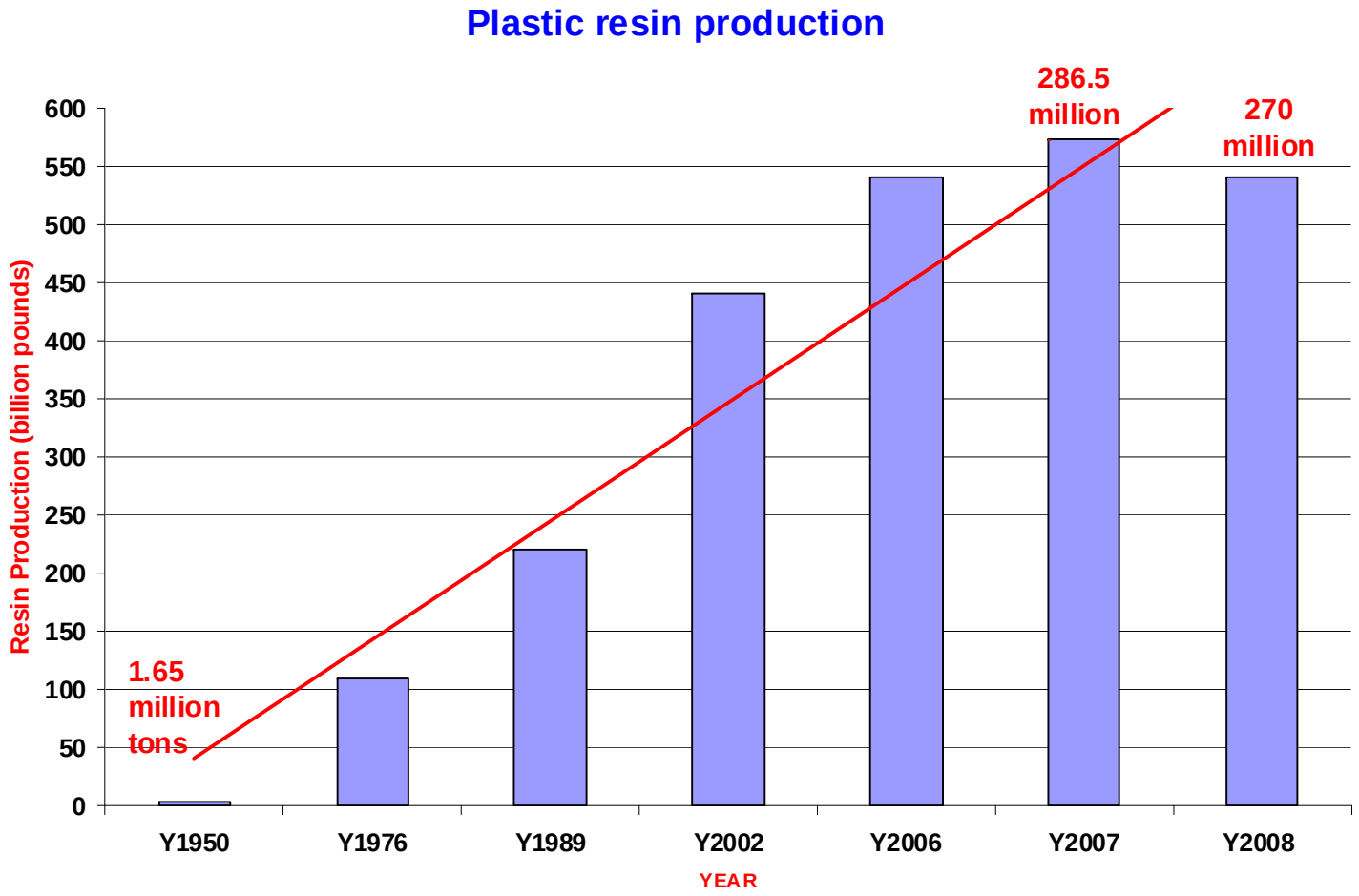
Biobased and Biodegradable/Compostable Plastics

Presentation at Southern Advanced Materials Webinar Series , January 12, 2010

Ramani Narayan
University Distinguished Professor
narayan@msu.edu

Plastics

- Plastics is ubiquitous



Two major problem/opportunity issues for plastics

- Carbon footprint reductions – global warming/climate change issue

- End-of-life for plastics
  - Recycling
  - Waste-to-energy
  - Biodegradability in targeted disposal systems like composting (compostable plastics)

What Value Proposition does BioPlastics offer?

Switching from the "petro/fossil" carbon in plastics to "bio-renewable" carbon reduces the material carbon footprint

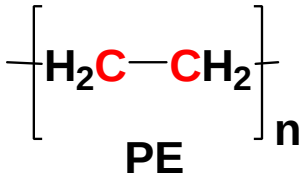
- **Reducing heat trapping CO_2 emissions -- Minimizing global warming/climate change problems**
    - **Global warming potential (GWP – LCA terminology)**
- **Using (renewable) biomass feedstock as opposed to petro/fossil feedstock – energy/environmental security**
- **Economic development – empowering rural farm, forestry and allied manufacturing industry**

CARBON FOOTPRINT BASICS – Value Proposition

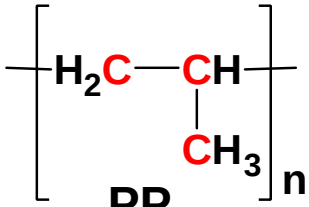
MATERIAL CARBON FOOTPRINT

PROCESS CARBON FOOTPRINT

Petro/fossil feedstock Oil, Coal, Natural gas → **Naptha** → **ethylene/propylene** → **Polyethylene (PE) polypropylene (PP)**



PE



PP

Bio/renewable feedstock

Crops & residues (e.g. Corn, soybean sugarcane)

Tree plantations Lignocellulosics

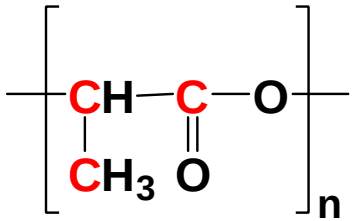
Algal biomass

→ **BIO monomers**

sugars, Oils

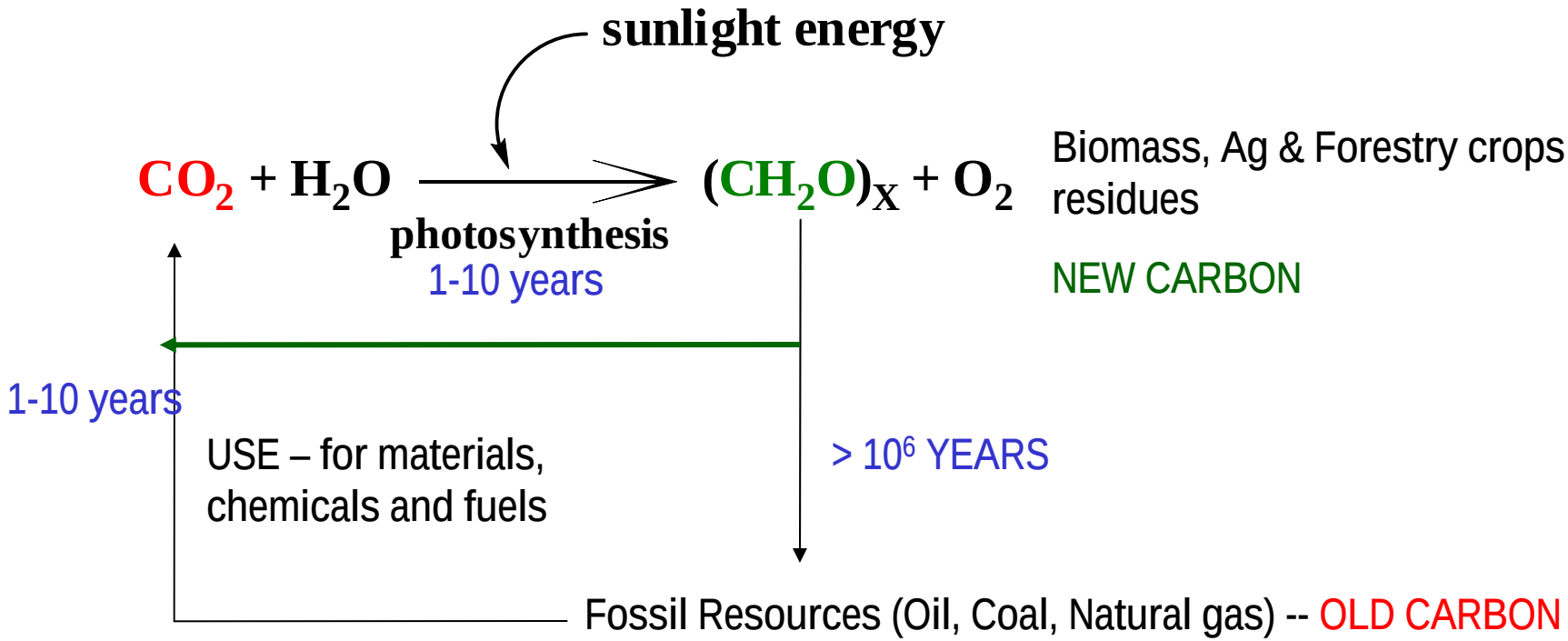
→ **EtOH**

→ **PLA, PHA's**



PLA

Understanding the Value Proposition for bio carbon vs petro/fossil carbon

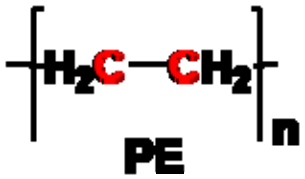


Rate and time scales of CO_2 utilization is in balance using bio/renewable feedstocks (1-10 years) as opposed to using fossil feedstocks

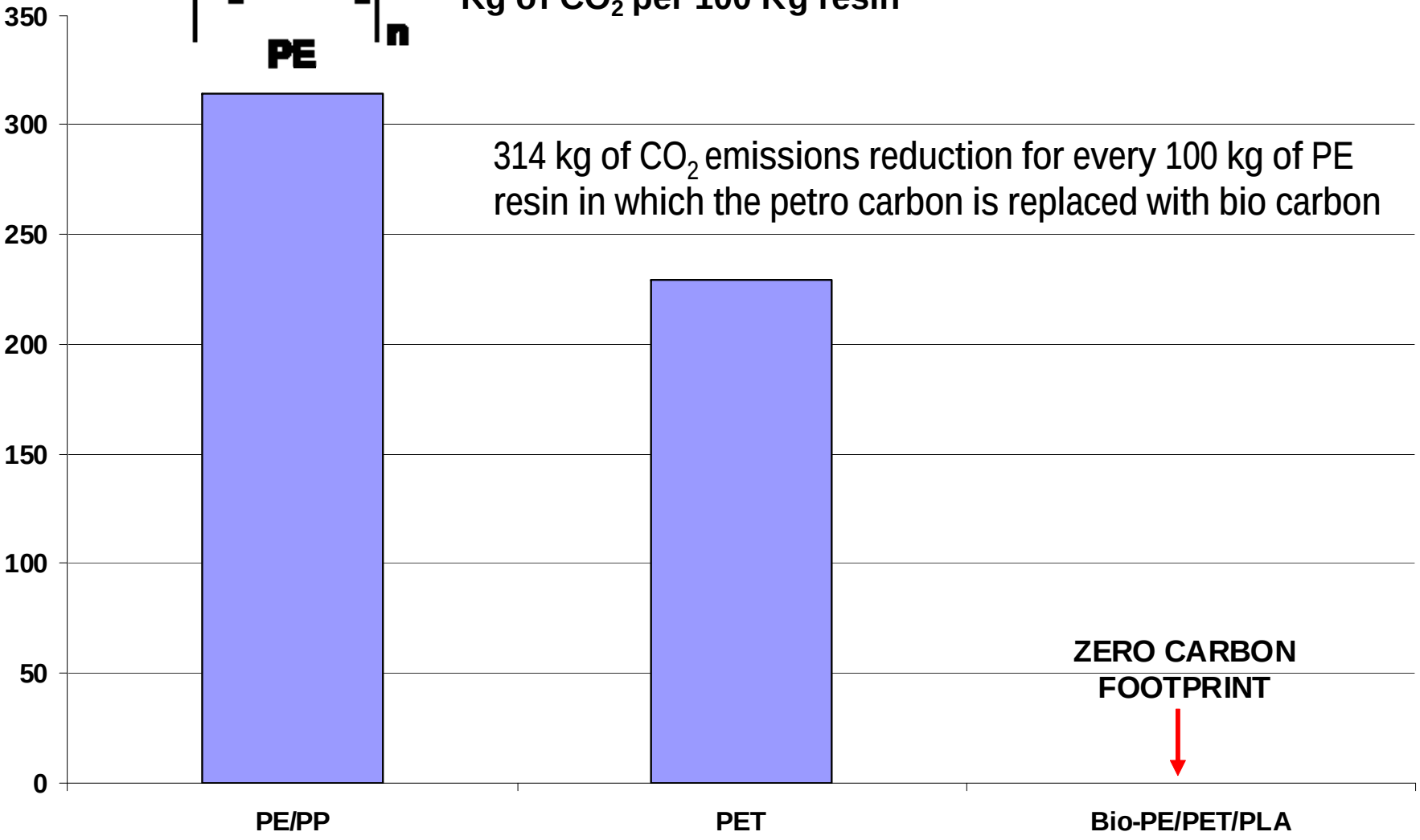
Short (in balance) sustainable carbon cycle using bio renewable carbon feedstock

MATERIAL CARBON FOOTPRINT

Material Carbon Footprint



Kg of CO_2 per 100 Kg resin

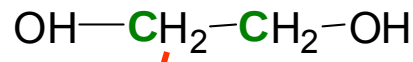


BIO-PET – Value Proposition

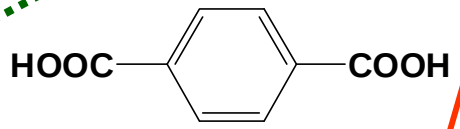
MATERIAL CARBON FOOTPRINT

PROCESS CARBON FOOTPRINT

Oil, Coal, Natural gas → **Naptha** → **Ethylene** → **Ethylene oxide** → **Ethylene Glycol**



EtOH



Bio/renewable feedstock

Crops & residues (e.g. Corn, soybean sugarcane)

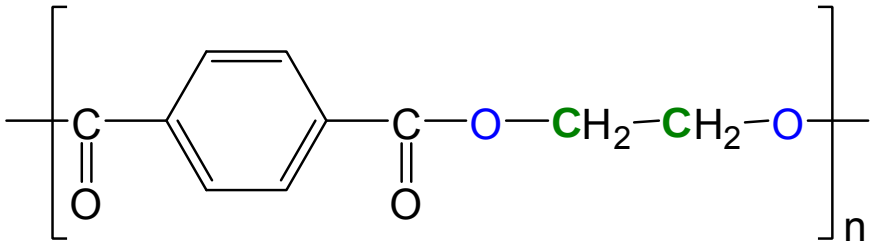
Tree plantations Lignocellulosics

Algal biomass

BIO monomers

Sugars, Oils

For bottles:
37.5 MM tons PET used
17.2 MM tons CO_2 savings
40 million barrels of oil/yr savings



BIOPET

PLANTBOTTLE

Measurement of bio (carbon) content – the Principle

$^{14}CO_2$ – Solar radiation

$^{12}CO_2$

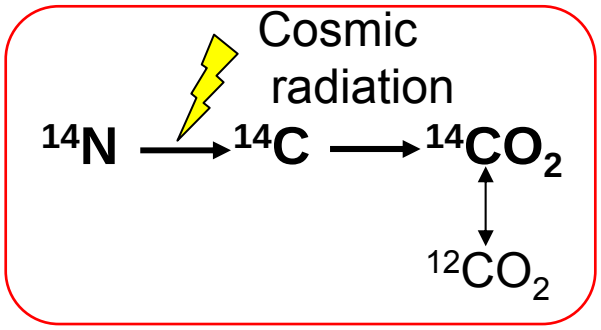
Biomass/Bio-organics

$(^{12}CH_2O)_x \longleftrightarrow (^{14}CH_2O)_x$

NEW CARBON

C-14 signature forms the basis of Standard test method to quantify biobased content (ASTM D6866)

$> 10^6$ years



Fossil Resources (petroleum, natural gas, coal)

$(^{12}CH_2)_n$ $(^{12}CHO)_x$

OLD CARBON

Narayan, *ACS (an American Chemical Society publication) Symposium Ser.939, Chapter 18, pg 282, 2006*

What is "Biobased or Biomass Plastics

Organic material/s containing in whole or part biogenic carbon (carbon from biological sources)

Organic Material/s **-- material(s) containing carbon based compound(s) in which the carbon is attached to other carbon atom(s), hydrogen, oxygen, or other elements in a chain, ring, or three dimensional structures (IUPAC nomenclature)**

Biobased (carbon) Content **-- Amount of bio *carbon* in the plastic as fraction weight (mass) or percent weight (mass) of the total organic carbon in the plastic. (ASTM D6866)**

% biobased content = Bio (organic) carbon/total (organic carbon) * 100

ASTM D6866 – Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis

Take home message is:

- **Carbon footprint from the conversion of feedstock to product – cradle to factory gate scenario and total environmental footprint must be calculated using LCA methodology ASTM D7075 or ISO 1440 and reported – the process carbon footprint**
- **BUT – the intrinsic value proposition for biobased plastics comes from the material carbon footprint reductions achieved and associated benefits.**

Biodegradability – A misused and abused term

- **Biobased plastic does not mean it is biodegradable and biodegradable plastic does not mean it is biobased!**

QUESTION

- **Can microorganisms present in the disposal environment utilize/assimilate the plastic carbon substrate – the biotic process**
- **What extent in what time frame**
- **Need complete removal in a short time frame – one year or less in that disposal environment**
    - **Degradable, partial biodegradable not acceptable – serious health and environmental consequences**
        - **Phil. Trans. Royal. Soc. (Biology) July 27, 2009; 364**

Measuring biodegradability

Microorganisms extract chemical energy for use in their life processes by the aerobic oxidation of glucose and other utilizable substrates – BIODEGRADBLE PLASTICS, food waste, paper, forest residues biological matter

AEROBIC

Glucose/C-bioplastic + 6 O_2 → 6 CO2 ↑ + 6 H2O; $DG^{0'}$ = -686 kcal/mol

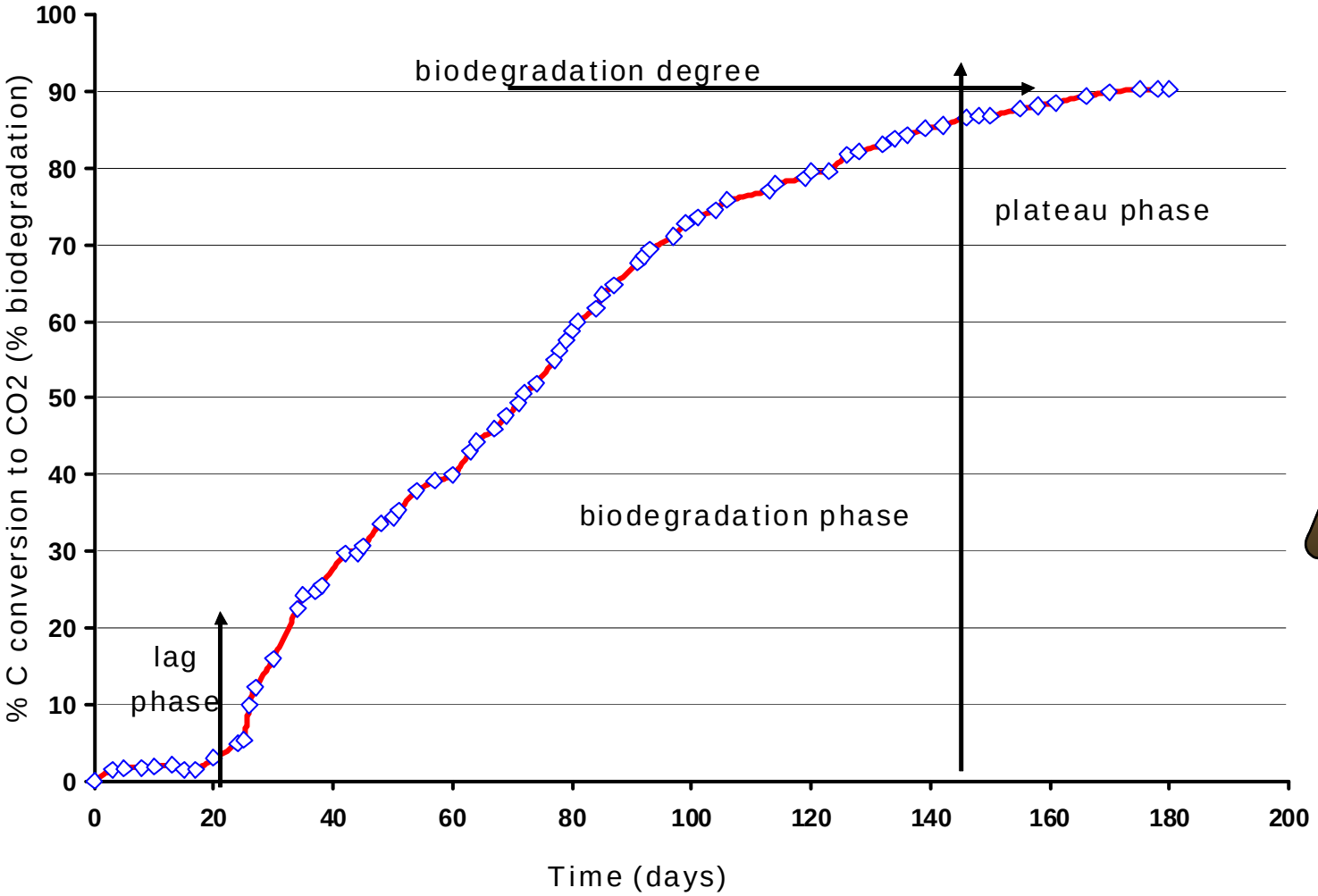
ANAEROBIC

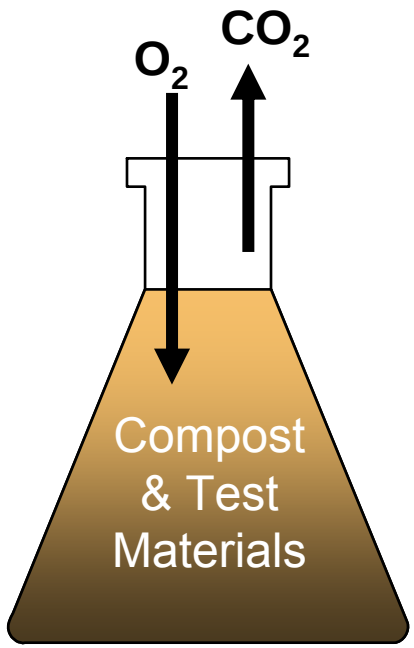
Glucose/C-bioplastic → 2 lactate; $\Delta G^{0'}$ **= -47 kcal/mol**

→ CO_2 + CH_4 ↑

CO_2 is the quantitative measure of the ability of the microrganisms present in the disposal environment to utilize/assimilate the test C-bioplastic, which is the sole C-source available for the microorganisms -- biodegradation/bioassimilation

Measuring biodegradability





Biodegradability under composting conditions

- **Specification Standards ASTM D6400, D6868, D7021**
- **Specification Standards EN 13432 (European Norm)**
- **Specification Standards ISO 17088 (International Standard)**

Biodegradability under marine conditions

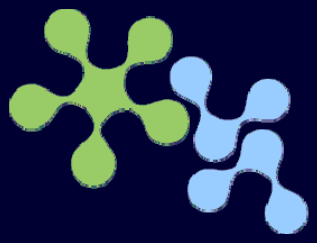
- **Specification Standard D 7021**

Biodegradability Test Methods – ASTM Standards

- **Soil D5988**
- **Anaerobic digestors D 5511, ISO 15985**
  - **Biogas energy plant**
- **Accelerated landfill D 5526**

- **Guide to testing plastics that degrade in the environment by a combination of oxidation and biodegradation ASTM D 6954**

Must provide results from the test methods – could be zero or 50 or 100 percent --- generally not provided but claim of complete biodegradability made



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THE BUSINESS OF BIOPLASTICS

www.bioplasticscouncil.org

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Market Overview

<1% of total plastics usage

Gaining market strength

Innovation is key – new resins, additives, applications

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Market Trends

- Improved price/performance spectrum
- Increase in sustainability measures (e.g., Wal-Mart)
- Public's and consumers' desire to be more "green"

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Challenges

- Terminology confusion
- Lack of infrastructure for organics recycling
- Limited legislative support
- Limited funding available

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Production and Growth

- Cereplast (Seymour, IN) – 8,000 tons/yr
- NatureWorks (Blair, NE) – doubled capacity to 150,000 tons/yr
- Telles (Clinton, IA) – 55,000 tons/yr
- Global demand expected to grow 35% annually from 2009-2013*

* Source – Freedonia Group

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Future Outlook

- Continuing consumer demand
- Adoption by brands (e.g., Frito-Lay, Coca-Cola)
- Development of bio-based feedstocks for commodity plastic resins
- Making inroads into markets dominated by more conventional plastics

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Activities in the South

- Production
  - DuPont/Tate & Lyle (Loudon, TN) – ↑ production capacity of Bio-PDO™ by 35%
- New resin development
  - Chicken feathers – Eastern Bioplastics (Mt. Crawford, VA)
  - Algae – Algenol (Bonita Springs, FL)
- Business development – LA

Q&A

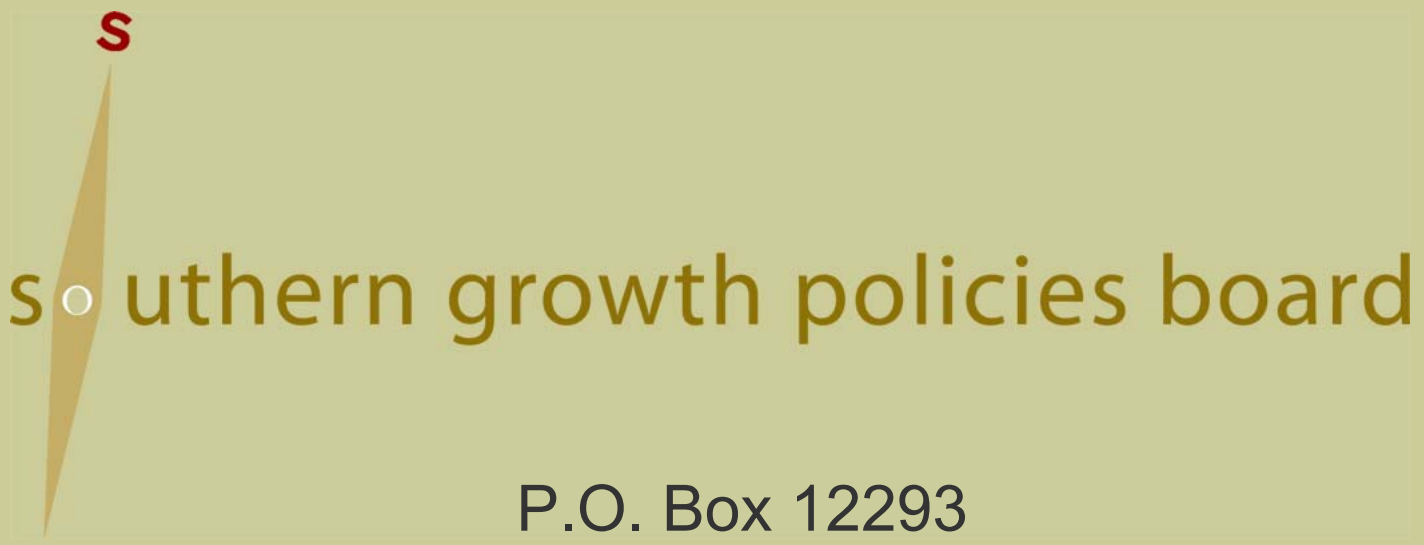
Next Steps:
Working Group on Bioplastics

- Email asking your opinion.
- Opportunity to join this working group.
- Contact me at sdoron@southern.org.

Next Advanced Materials Webinar:
Advanced Composites

February 16, 11:00 EST

- **Les Goff**, President & CEO,
  Noetic Technologies
- **Bryan Brister**, Director, MS Polymer Institute,
  University of Southern Mississippi



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